In re Patent Application of CHEW, Kai Hwa et al.

Serial No.: 09/932,793

Filed: August 17, 2001

For: *Improvements in or Relating to Solders*

Declaration of Chew Kai Hwa Under 37 C.F.R. § 1.132

I, Chew Kai Hwa, state and declare as follows:

1. I am one of the inventors named in the patent application identified above.

2. I have a degree in Chemistry from the National University of Singapore. I have substantial experience in the field of solder chemistry, including among other experience, over 12 years of experience in researching and developing solders. My experience in working with solder chemistry includes substantial manufacturing, research and application process experience. I have acted as consultant to industrial companies, including Panasonic and Sony, in relation to solder applications.

3. I have reviewed the specification, drawings and amended claims in the application identified above, and have reviewed the patents cited by the Examiner in the application. I have also reviewed the Office actions dated September 26, 2002, and more recently, March 24, 2003. For the reasons set forth below, I believe that the solder composition set forth in the claims as currently amended is patentable over the prior art references.

4. Each of the claims in the application is amended to specify several important criteria, and these criteria are essential in distinguishing the claimed invention from the solders disclosed in the prior art references cited by the Examiner. All of the claims are now directed to either a solder for use in a wave-soldering process, or a method of soldering using a wave-soldering process. Wave-soldering is a process that is of course well-known in the art, and it is a very different process from other methods of soldering such as Surface Mount Technology (SMT) soldering. As such, the solder requirements are very different for these two types of soldering processes. As explained in the specification at paragraph 44:

> In an example of wave-soldering, a circuit board is held just above the surface of a quantity of molten solder in a pot. A wave is then caused to propagate across the surface of the

molten solder, of sufficient amplitude that the crest of the wave comes into contact with the surface of the circuit board. The wave is as wide as the circuit board (or the portions thereof that require soldering), and as the wave propagates across the surface of the molten solder all parts of the downward-facing surface of the circuit board are contacted with molten solder.

Because the solder pot in a wave-soldering machine holds the alloy in a molten state at high temperatures (at least about 245° C), the alloy is prone to oxidation and skinning and this is a significant problem that must be solved. Oxidation and skinning are not concerns with SMT soldering.

Experimental data from our research indicates that phosphorous is a necessary component of the claimed solder. Moreover, the preferred percentage of phosphorous is 0.01% (see specification, paragraph 22—Alloy "349"). When phosphorous is present in this amount, the composition works as a drop-in replacement for lead solders in a wave-soldering machine. We have found that when phosphorous in the alloy in an amount greater than the preferred percentage of 0.01, then the alloy will experience increased brittleness, which impairs the reliability of the solder joint fillet. If phosphorous is included in an amount greater than 0.50%, the alloy is too brittle to perform reliably. On the other hand, if phosphorous is omitted from the alloy the result is unacceptable skinning and oxidation in the solder pot.

5. The experimental data set forth in the specification supports the foregoing. Specifically, in the fillet lifting test set forth in Figs. 9, 10A and 10B, and as detailed in the corresponding portions of the specification (Test 3, paragraphs 38-40), alloy 349 (91.39% tin, 4.2% silver, 4.0% indium, 0.5% copper and 0.01% phosphorous) demonstrates the ability to eliminate fillet lifting defects. As a further example, in the drossing test (Test 5, paragraphs 44-48 and Fig. 13) the drossing of the claimed invention was lower than all but one of the other lead-free solders and is lower than the drossing found with the conventional lead-containing solder.

The remaining test data provide further support for the patentability of the claimed alloy for use in wave-soldering. Thus, the claimed lead-free solder is very suitable as a direct replacement for conventional lead-containing solders, due to the comparable characteristics of wettability, fluidity, compatibility with existing component coatings, fillet lifting and drossing.

6. As noted previously, I have reviewed the prior art references cited by the Examiner. I do not believe that the invention set forth in the claims of my application are either disclosed by any of the prior art references, or made obvious in view of any combination of those references. The prior art document

cited by the Examiner Jphosphorous2001/058286 suggests adding 0.2% phosphorous as an antioxidant. However, the alloy disclosed in this application is intended for use in a SMT process and does not address the problem of formulating a drop-in replacement for lead solder in a wave-soldering process.

7. As noted above, oxidation and skinning are substantial concerns in a wave-soldering process because the alloy is held in a molten condition for extended periods of time. My fellow inventor and I have found that the alloy claimed in the application in which phosphorous is present in an amount not more than 0.01% demonstrates minimal oxidation and skinning.

8. I believe that the alloy claimed in my application would not have been obvious to one of ordinary skill in the art in view of any combination of the references cited. The Jphosphoroua2001/058288 reference does not teach use of phosphorous in a solder for use in wave-soldering, and does not teach use of phosphorous at the level found in the claims. Moreover, the alloy taught by the Japanese reference just mentioned is very different from the claimed invention in other respects, including the fact that the alloy in the Japanese reference calls for a tin/silver base containing only 0.2 ~ 1% silver, with small amounts of antimony and/or copper or nickel, cobalt, iron, manganese, chromium and/or molybdenum as strengthening agents, bismuth indium and/or zinc as melting point-lowering elements, as well as phosphorous, gallium and/or germanium as antioxidants. In sum, the SMT solder alloy disclosed in this Japanese reference is for a fundamentally different process, and is a fundamentally different alloy.

9. In view of the fact that our experimental data have shown that phosphorous is a necessary compound in the claimed alloy, and that when present in an amount greater than 0.01%, we believe that the presence of phosphorous in this amount is crucial, and distinguishes the invention defined in the claims from the prior art. Although as detailed in the specification, phosphorous may be used in an amount up to 0.5%, we have found that if phosphorous is present in an amount greater than 0.01% (as now claimed), then the solder demonstrates some brittleness. The optimal and critical amount of phosphorous is thus set forth in the claims.

10. I would also like to add that the general experience is that it is not an easy task to control a quaternary alloy in the wave soldering process. As a consequence nobody ever works wave soldering processes with a quaternary alloy. To date, most people in the field are still working with binary alloys with a few using ternary alloys and there are a considerable number of patents relating to such alloys. Segregation of elements in quaternary alloys is a major concern that people in the industry have been unable to control. However, the alloy developed by me and my fellow inventor as described in the present Application is in fact stable enough to counter this issue and thus enables the use of a quaternary alloy in wave soldering, a possibility previously dismissed as

unworkable by people in the industry. The stability of the alloy of the present invention when used in wave soldering has already been proved by our customers, one of whom has already successfully used the solder in use in one of his wave soldering pots for more than 16 months in a normal wave soldering system which was formerly operated using conventional tin/lead solder.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Dated: August 11, 2003

Chew Kai Hwa